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X-ray/IR Study of Supernova Remnants with
Center-Filled X-ray Morphologies

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This grant was to carry out archival research using the *Einstein* and *IRAS* databases of an unusual class of galactic supernova remnants characterized by limb-brightened radio morphologies and centrally peaked X-ray surface brightness distributions. We proposed to analyze data which was available on these objects and to carry out theoretical calculations in order to explain the data.

The basic results of our research were as follows:

- [1] We constructed a list of all those supernova remnants known to have centrally peaked X-ray morphologies and shell-like radio surface brightness distribution. We inspected all of the IRAS data available on these objects to see whether any of these sources had been detected; none had been detected with high certainty which allowed us to put upper limits on the IR fluxes of individual supernova remnants.
- [2] We carried out an X-ray spectral analysis of the supernova remnants. The spectra can all be fit to thin plasma models of their X-ray emission; most if not all can be fit with power law models as well. There are no obvious changes of spectral shape as a function of position in the supernova remnants which can be attributed to a difference in temperature of an assumed plasma at the center and edge of the supernova remnants. In one case, W28, there was a significant change in the apparent hydrogen column density along the line of sight.
- [3] We carried out a detailed analysis of two supernova remnants, 3C400.2 and W28, for which the X-ray data was quite good. We explored various models for the X-ray emission including the possibility that the structure of the SNR was that of a typical Sedov SNR (i.e. with most emission in a shell) but that absorption along the line of sight modifies the apparent morphology. We concluded that this was unlikely and that it was more probable that the observed morphology was due to evaporation of clouds in the hot interior of the SNR.
- [4] We developed new similarity solutions for supernova remnant evolution which incorporate cloudlet evaporation. Depending upon the rate of evaporation the predicted morphology varies from that of the standard limb-brightened Sedov

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solution to surface brightness distributions which are similar to those observed in 3C400.2, W28, and other remnants with centrally peaked X-ray morphologies.

We have documented our research in two manuscripts which are currently being reviewed for publication in the *Astrophysical Journal*. The titles and authors of the papers are as follows:

- [1] "W28 and 3C400.2: Two Shell-like Radio Supernova Remnants with Centrally Peaked X-ray Morphologies", by K. S. Long, W. P. Blair, R. L. White and Y. Matsui, and
- [2] "Supernova Remnant Evolution in a Cloudy Interstellar Medium", by R. L. White and K. S. Long.

Copies of the manuscript are attached.